Combined Heat and Power Using Combustion Turbines

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Solar Turbines Incorporated

Combined Heat & Power (CHP) or Cogeneration

Simultaneous Production of Power and Process Heat from Single Fuel Source

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CHP Characteristics

- Provides Both Electric Power and Thermal Energy
- Extremely High Efficiency
- Continuous Operation
- Proven Technology
- System Availability Very Important
- May Use Steam Turbine and/or Process Steam

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CHP Economic Factors

- Need for RELIABLE Electric and Thermal Energy
- Facility Heat to Electricity Ratio > 1.3:1
- Electricity Price to Gas Price Ratio of 2:1
- Continuous Operation

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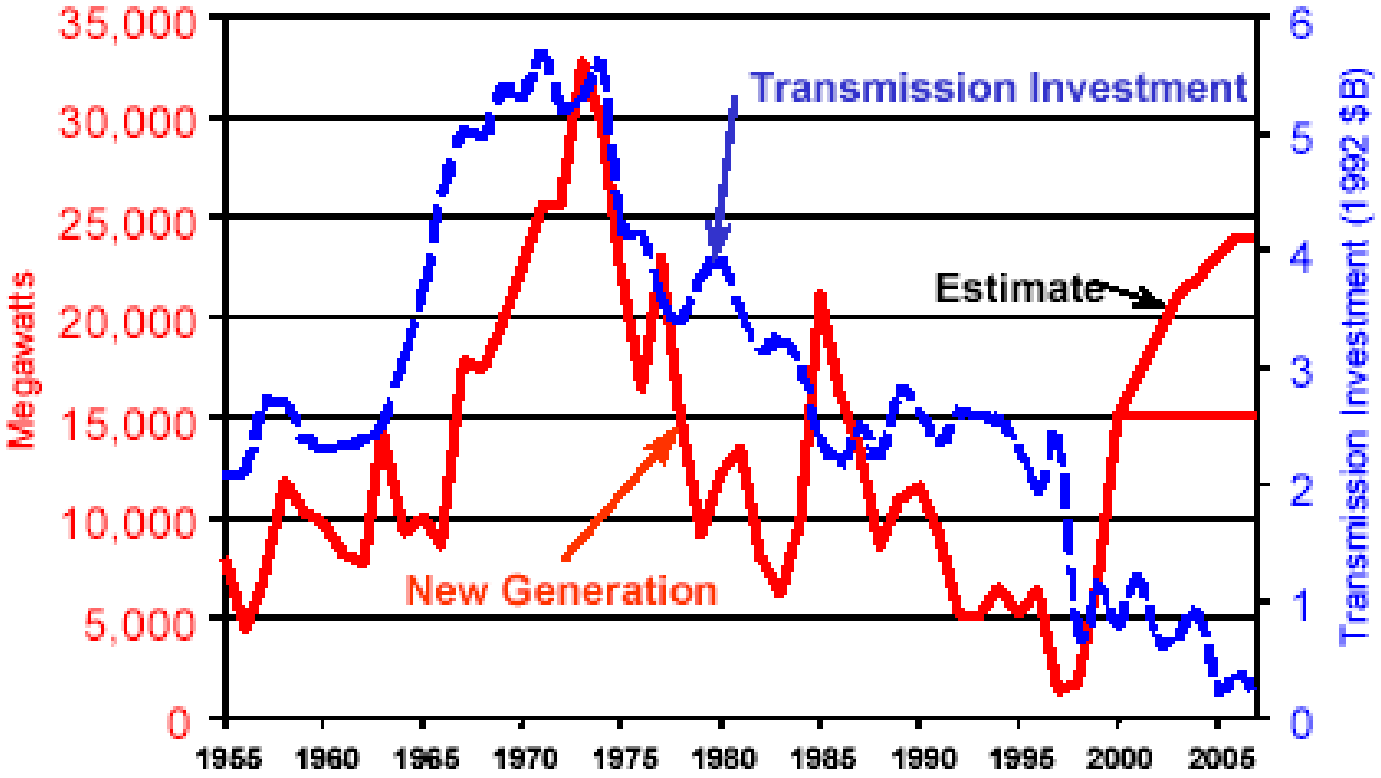
De-Coupling of Investment in U.S. Generation & Transmission



Source: Cambridge Energy Research Associates, Electric Transmission Advisory Service, 2000

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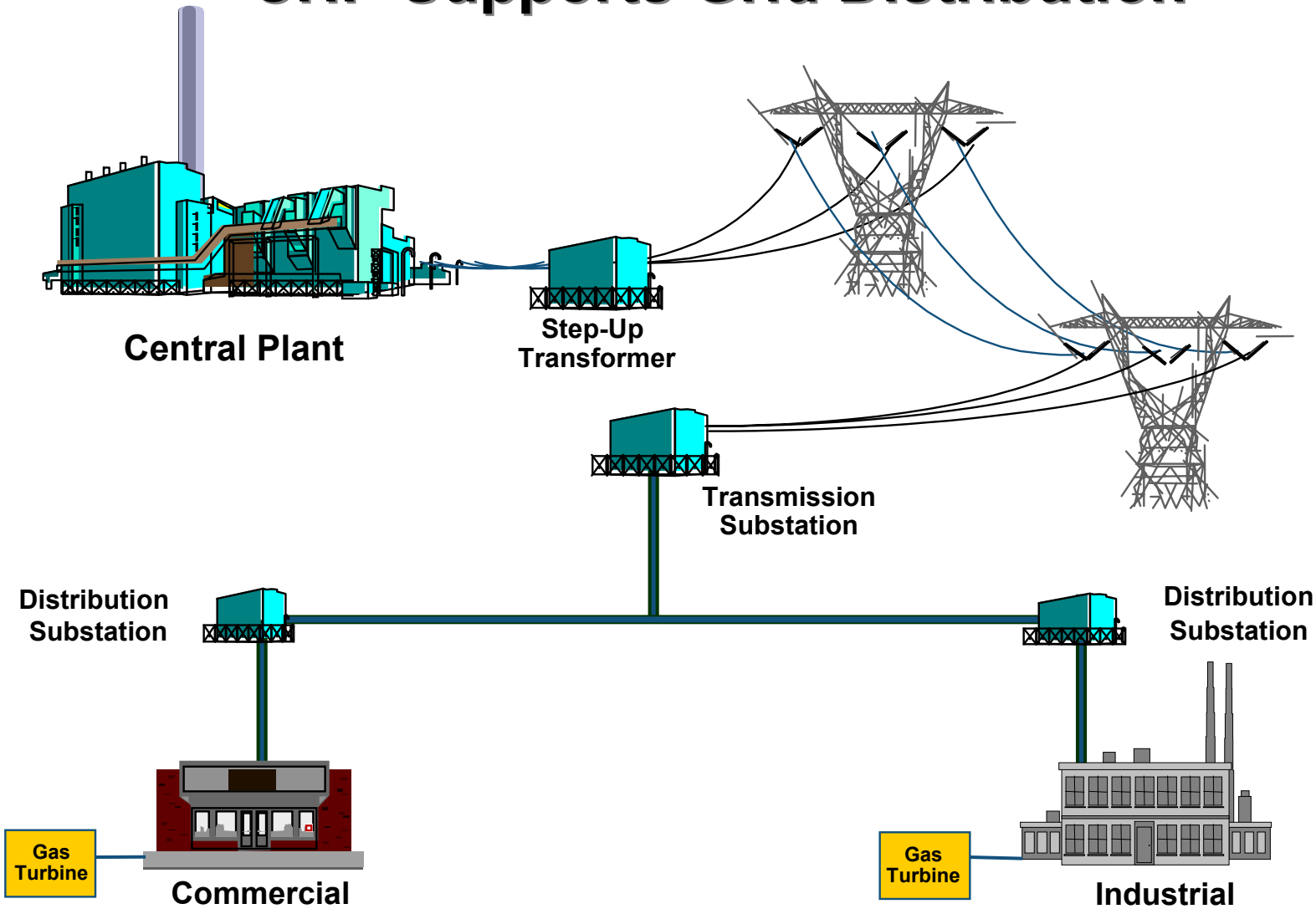
CHP Supports Grid Distribution



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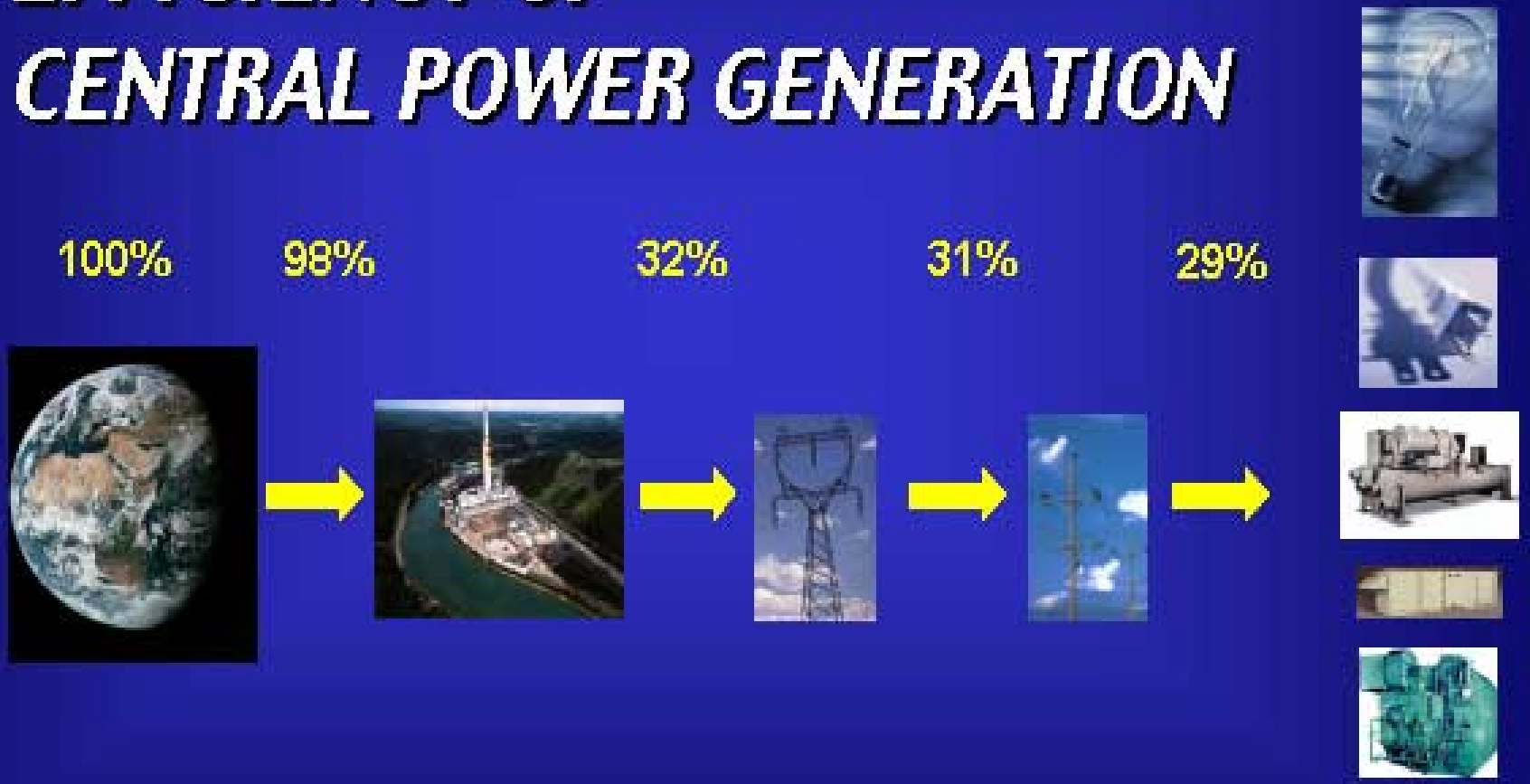
EFFICIENCY OF CENTRAL POWER GENERATION



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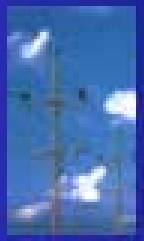
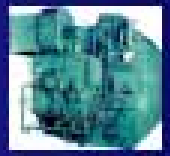
EFFICIENCY OF POWER DISTRIBUTED COMBINED CYCLE

100% → 91% → 50% → 48%





NATURAL RESOURCE

COMBINED CYCLE POWER PLANT

DISTRIBUTION

END USES

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DELIVERED EFFICIENCY OF BCHP

30% to 50% Electrical

50% to 30% Thermal

100%

91%

or

80%

or

NATURAL RESOURCE

BCHP POWER PLANT

END USES

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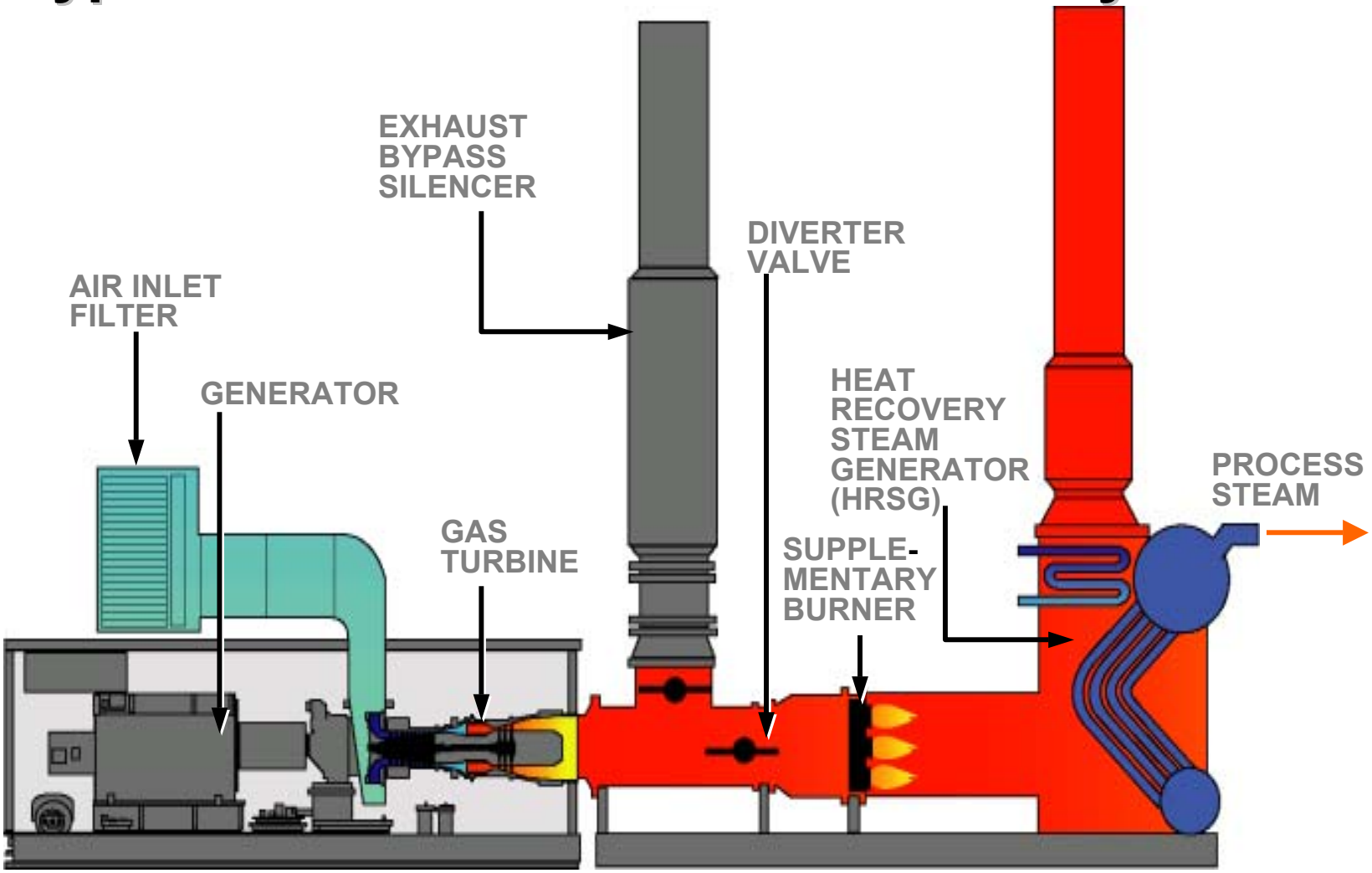
Typical Combined Heat and Power System



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10 MWe Cogeneration Plant

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CHP System Performance

Product	Power MWE	Exhaust Energy MMBtu/hr	Steam Flow Unfired		Steam Flow Duct Fired to 1700°F	
			lb (000)/hr	% Efficiency	lb (000)/hr	% Efficiency
Saturn 20	1.2	11.7	8.8	72	19.7	85
Centaur 40	3.4	28.7	18.8	69	56.1	84
Centaur 50	4.4	34.4	24.0	74	57.4	85
Taurus 60	5.4	38.7	30.0	73	67.8	87
Taurus 70	7.4	47.4	32.3	75	81.9	87
Mars 100	10.4	71.8	48.6	75	125.8	87
Titan 130	13.7	86.4	62.7	79	150.4	87

ISO Conditions: 59°F (15°C), 3 In. Inlet, 7 In. Exhaust Losses, Sea Level, and Saturated Steam @ 150 psig

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Typical CHP Installations

Taurus 60 with Hi Fired HRSG
for a University

Centaur 40 with HRSG and SCR
Pharmaceutical Manufacturing Plant
Irvine, California

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CHP Experience

Application	Units
Airports	8
Breweries	14
Ceramic Manufacturing	55
Chemical / Petrochemical / Pharmaceuticals	123
Communications	24
District Heating	2
Food Processing	127
Government-Owned Power Generation	17
Hospitals	45
Hotels	4
Independent Power Producers (IPPs)	9
Investor-Owned Utilities	39
Landfill / Waste Treatment	29
Manufacturing	66
Mining	26
Municipals/Rurals/Cooperatives	86
Pulp and Paper	180
Textiles	58
Tires and Rubber	11
University / Research Facilities	61
Other Commercial	30
Other Industrial	100
Oil and Gas Applications	486
Total	1600

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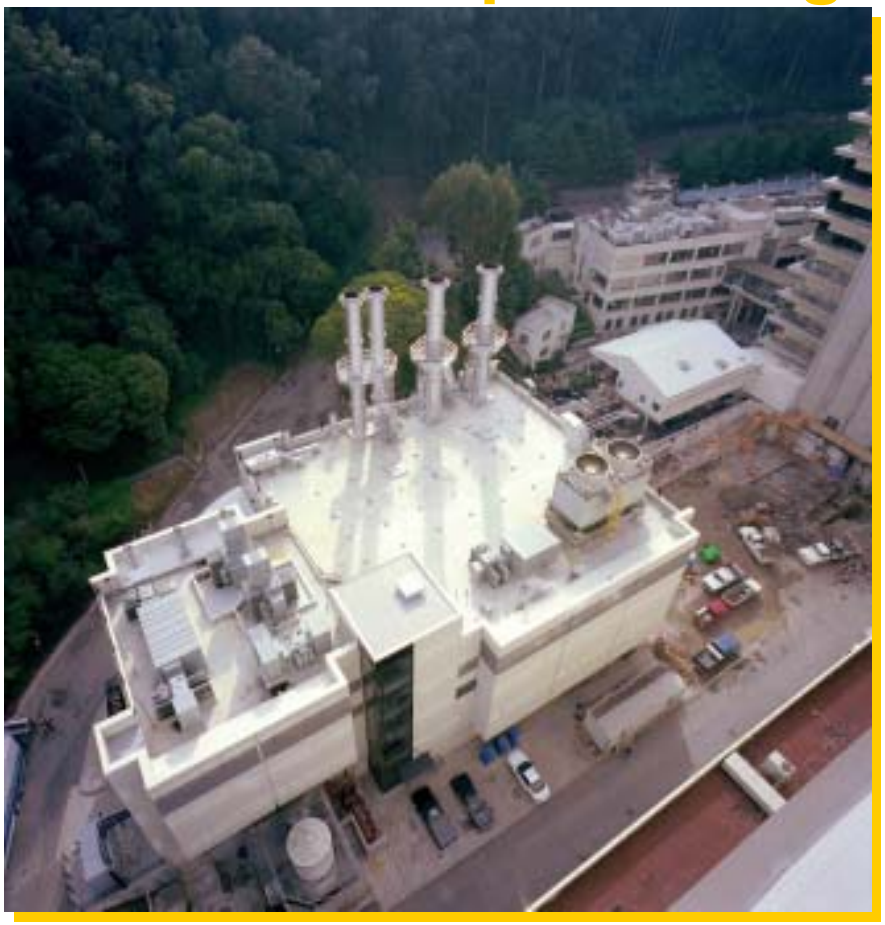
UCSF Hospital - Cogeneration



Full Operation and Maintenance Provided by Solar

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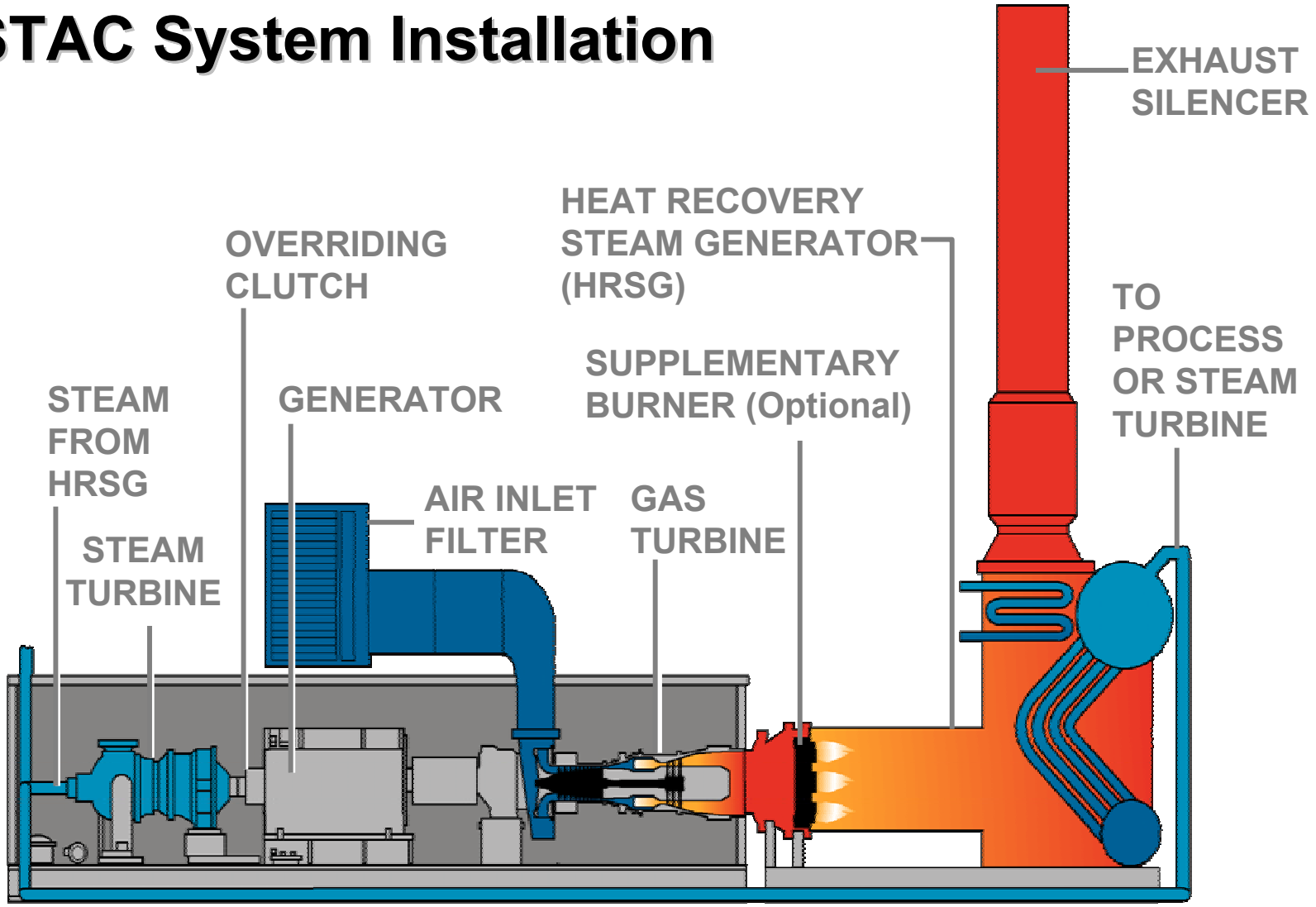
STAC System Installation



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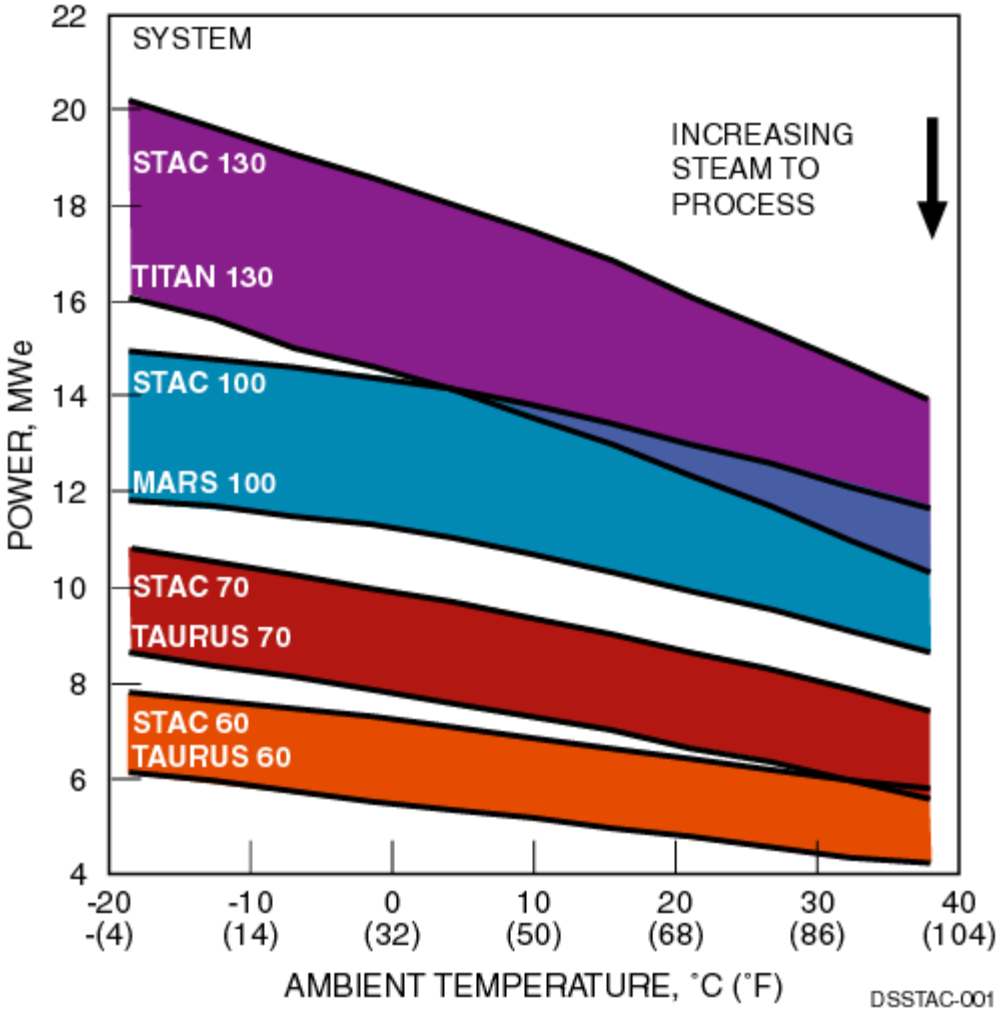
STAC Performance Coverage



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Rice University

7 MWe Combined Cycle Plant

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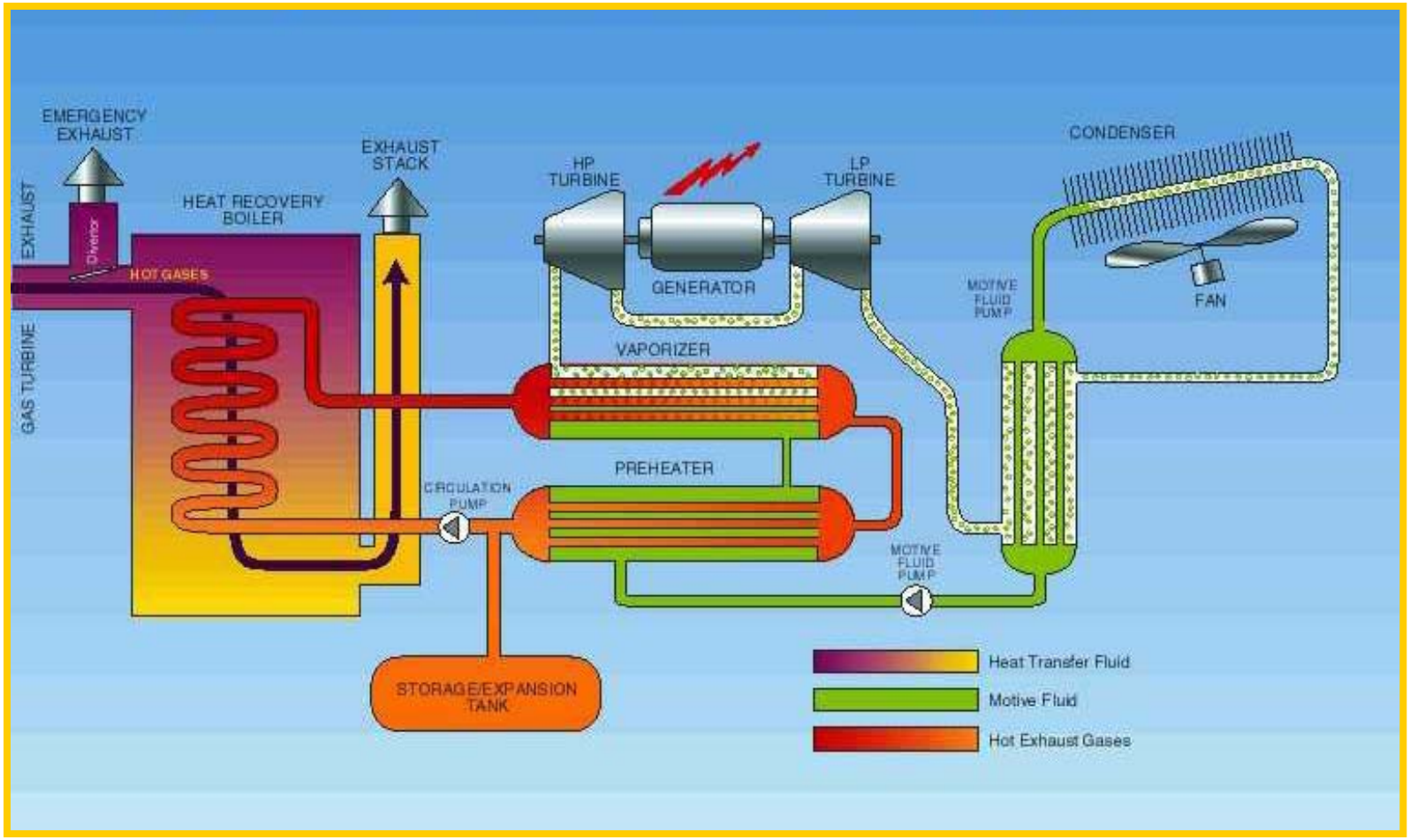
Operating from Gas Turbine Exhaust Heat



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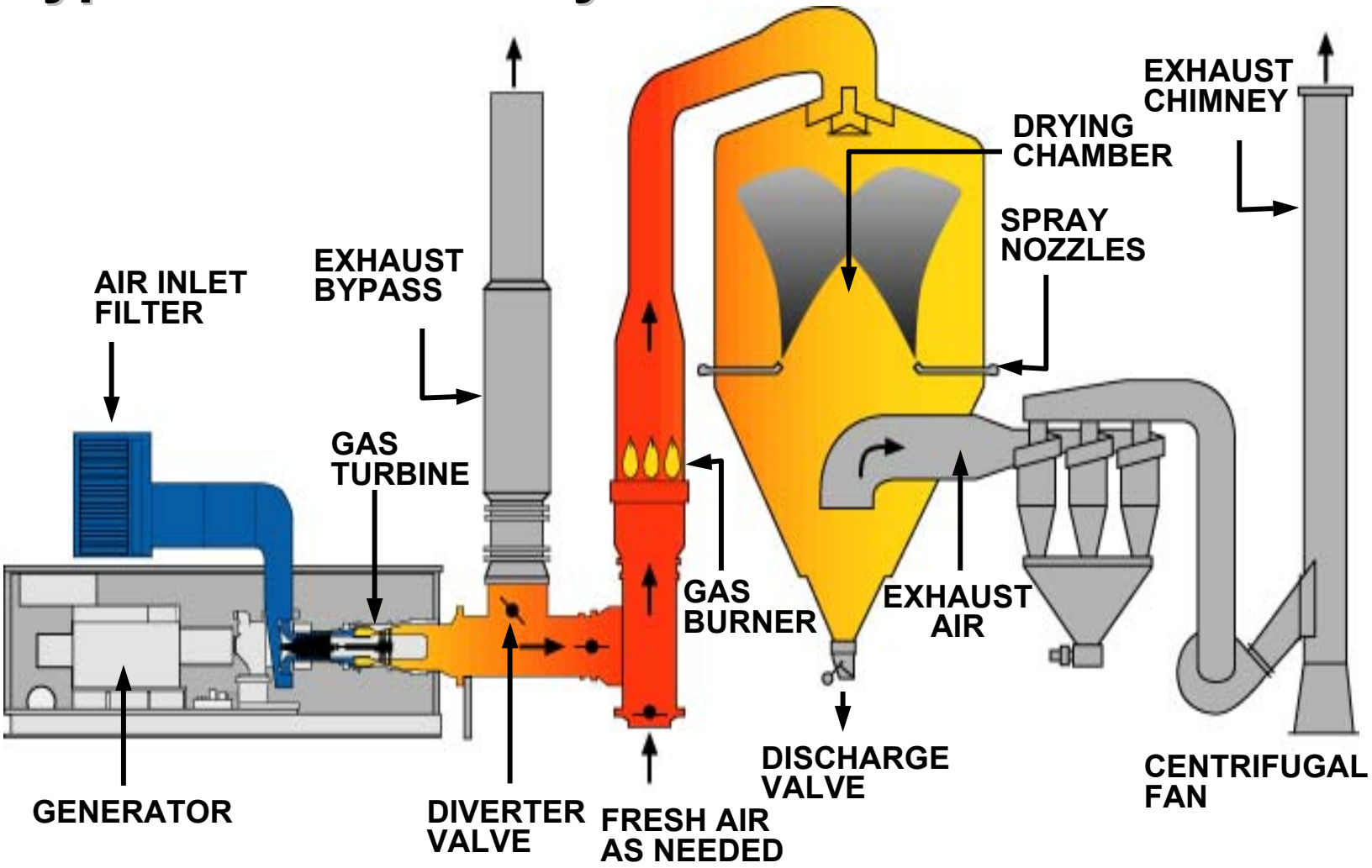
Typical Ceramic Dryer



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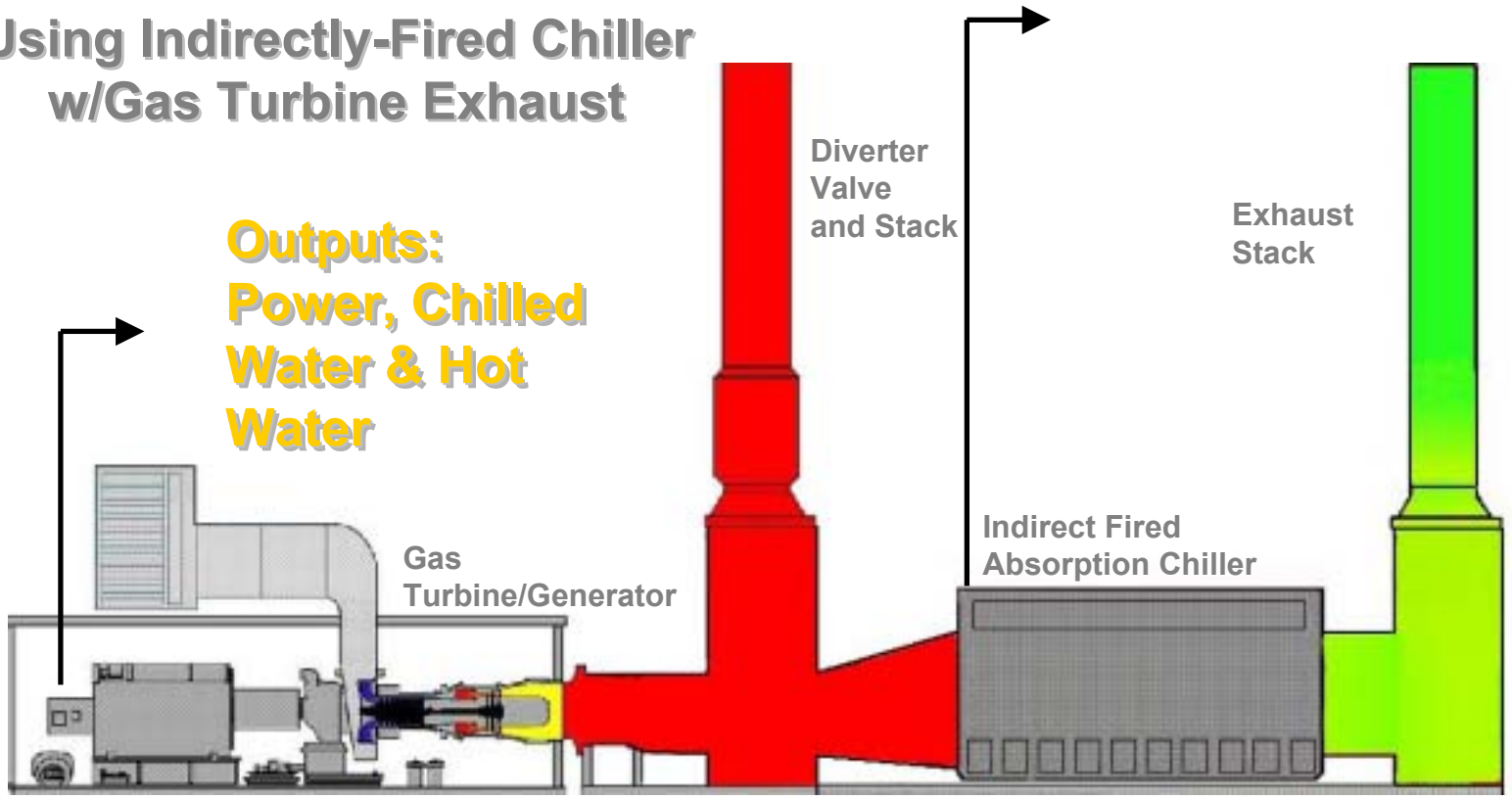
Building Cooling, Heating and Power (BCHP) Design

Using Indirectly-Fired Chiller w/Gas Turbine Exhaust

Outputs: Power, Chilled Water & Hot Water



Example Package Footprint:
Saturn BCHP - 10' x 76'
Centaur 40 BCHP - 10' x 85'

Smooth, quiet operation - < 85 dBA at 1 meter

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BCHP Capabilities

Engine Family	KW Output	Chilling, Tons	Heating, MMBTU/hr
Saturn 20	1200	855	7.4
Centaur 40	3400	1900	16.1
Centaur 50	4600	2500	21.6
Taurus 60	5400	2900	24.9
Taurus 70	7500	3300	28.2

Data above at ISO conditions, 59°F, sea level
Assumes double effect absorption chillers
Exhaust fired chiller can produce hot water temperatures up to 200°F

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Heat Recovery Absorption Chilling

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Steam Absorption Chilling System

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Steam-Turbine-Drive Chiller

- 350-2100 tons capacity range
- R-134a refrigerant

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20 MWe CHP Plant in Texas

Turnkey Constructed, Financed, Operated & Maintained by Solar

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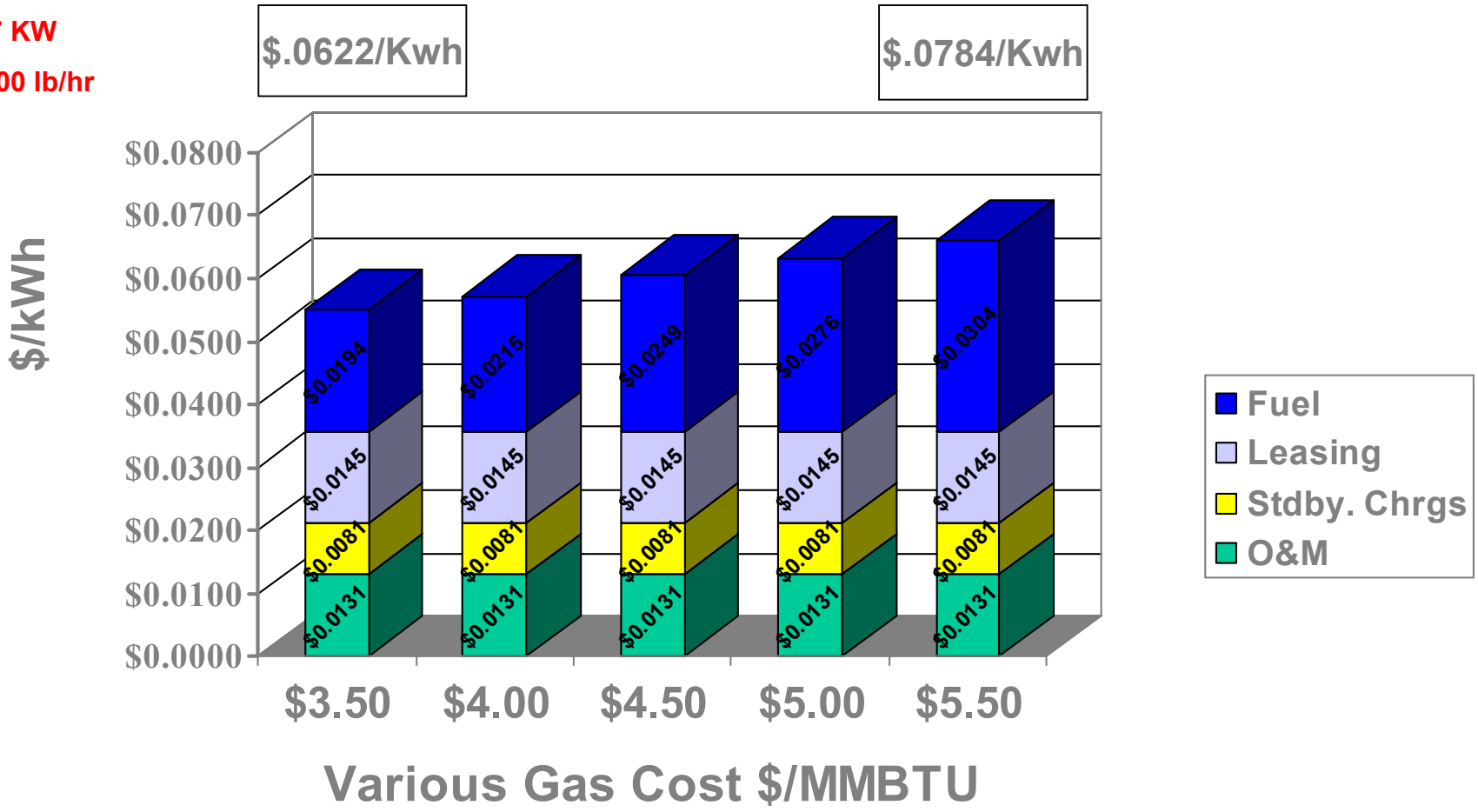
TAURUS 60 CHP Energy Service Contract kWh Rates

5257 KW

30,000 lb/hr



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42 MW Peaking Plant

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Mobile Power Unit

- 5 and 14 MW Configurations
- Easy to Install and Relocate
- No Concrete Foundation
- Easy to Permit
- 25 ppmv (Gas Fired)
- Sound Attenuated Package
- Designed for Remote Operation

- Highest Power Density Available
- Ideal for Urban Installations
- Flexible Ownership Terms
- Rental
- Purchase
- Lease

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Technology Comparison

Technology Comparison	Diesel Recip	Gas Recip	Simple Cycle Gas Turbine	Micro turbine	Fuel Cell	Photo-Voltaics
Size Range (eKW)	20 – 10,000	50 – 50,000	1000 +	30 – 200	50 – 1000 +	1 +
Efficiency HHV	36-43 %	28-46 %	21-30 %	25-30 %	35-54 %	n. a.
*Genset Pkg Cost	125 – 300	250-600	300-600	350-750	1500-3000	n. a.
*Turnkey w/o Heat Rec	350-500	600- 1000	650 – 900	600 -1100	1900 - 3500	5000 – 10, 000
*Heat Recovery	n. a .	75 – 150	100 – 200	75 – 350	Incl	n. a.
*O & M Costs	.005 - .01	.007 - .015	.003-.008	.005-.015	.005-.010	.001-.004

* Cost in $/eKW

Source -- GTI Distributed Generation Forum 2000

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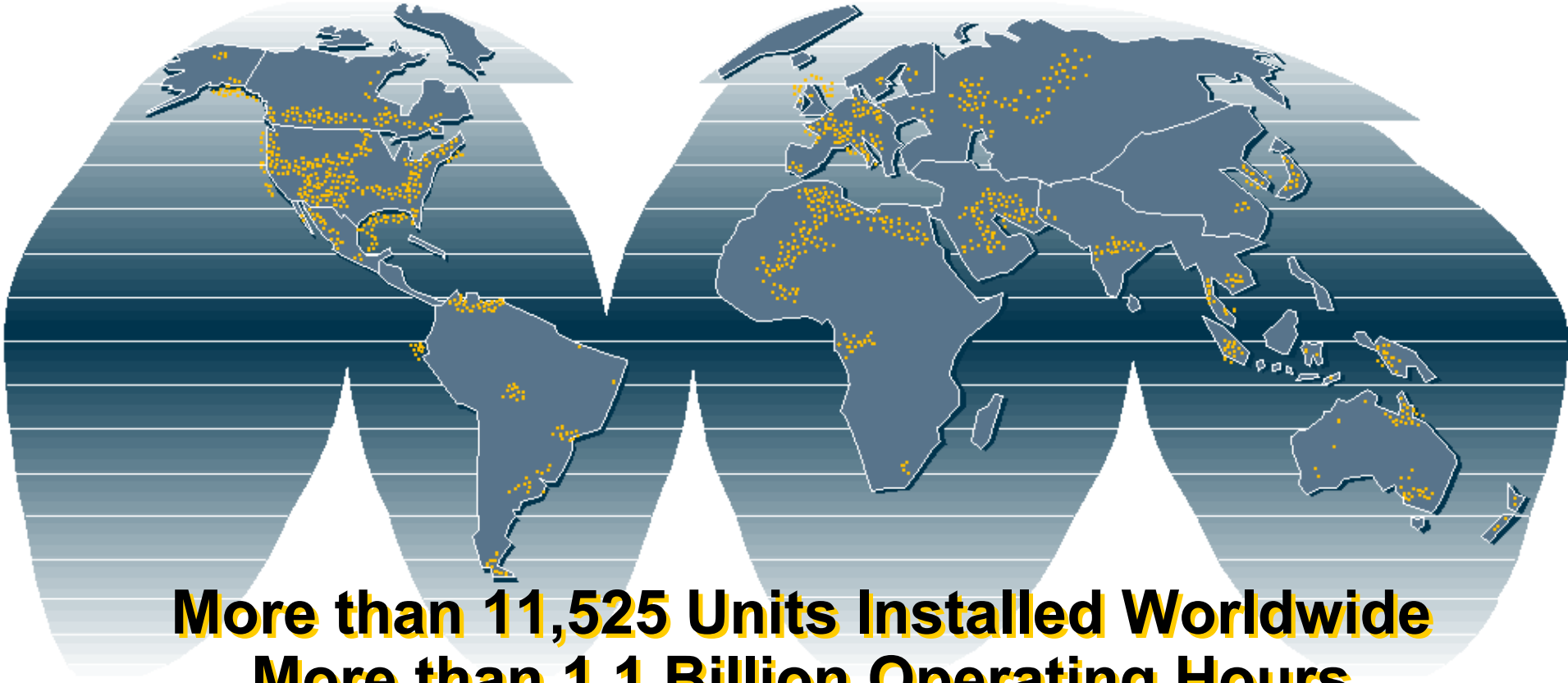

More than 11,525 Units Installed Worldwide
More than 1.1 Billion Operating Hours
More than 5950 Generator Packages,
2250 Mechanical Drives, and
3325 Compressor Sets

Questions?